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TWENTY-NINTH
PROGRESS REPORT
OF

THE FIRESTONE TIRE & RUBBER CO.

ON

105 MM BATTALION ANTI-TANK PROJECT

Contract No.
DA-33-619-ORD-33 (Negotiated)
RAD ORDTS 1-12383

THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio
DECEMBER, 1952

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ABSTRACT

An inventory of recoilless rifles and mounts, manufactured by Firestone, for both the BAT and ONTOS projects, is presented. Proposed design changes on the T137E3 rifle are discussed and the features of two new mounts, in process, are given. Tests with a special double-base powder, in four web sizes, are reported.

A group of T119 projectiles were fired from a T19 recoilless rifle at Erie Ordnance Depot. The firing data are presented. Tests were conducted with the T119E11 projectile being fired from a 105mm howitzer. Strength tests of the projectile, charge development studies and flight tests (all fired from M2A1 howitzer) are discussed and test data are presented. A program is presented for continuing the development of the T119 projectile and the phases to be investigated are discussed. An accounting of T119 projectile shipments is given.

Four phases of penetration studies were investigated during this report period. They are: the effect of standoff on machined and drawn liners, the effect on penetration of internal tee configuration, the effect of riser material in loading Comp B and the effect of tee material. The test data are presented and analyzed.

Tests were made with T222E5 fuze base elements for explosive train check and for investigating detonator safety. Comparison tests were made with the T222E5 and T208E5 base elements. Five penetration assemblies using DRC439 fuzing systems were fired. The test details are given and discussed.

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THE WEAPON SYSTEM

An inventory of recoilless rifles and mounts manufactured by Firestone for

the BAT and ONTOS projects is presented in Table I.

Table I
Inventory of Recoilless Rifles and Mounts
Manufactured by Firestone for BAT and ONTOS Projects

Rifle or Mount	Location	Comments
<u>T137E3 Rifles</u> Ser. No. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Fort Benning Fort Benning Fort Knox Fort Knox Aberdeen Proving Ground Fort Benning Fort Benning Fort Knox Fort Benning Fort Benning Fort Knox Not Completed Aberdeen Proving Ground Not Completed Erie Ordnance Depot	BAT Evaluation Test " " " T165 ONTOS Ser. No. 5 T165 ONTOS Ser. No. 7 Engineering Test T166 ONTOS Ser. No. 2 T165 ONTOS Ser. No. 6 T166 ONTOS Ser. No. 5 T165 ONTOS Ser. No. 6 T166 ONTOS T165 ONTOS Ser. No. 7 To replace No. 5 For Acceptance Test on T152E4 No. 6
<u>T137E2 Rifles</u> Ser. No. 1 2	Akron Akron	Used for spare parts Erie Ordnance Depot for proof facility.
<u>T137E1 Rifles</u> Ser. No. 1 2 3 4 5 6 7 8	Aberdeen Proving Ground Akron (E. O. D.) Aberdeen Proving Ground Aberdeen Proving Ground Akron Akron Akron Akron	To be returned to Akron To be returned to Akron Sent to Watertown Arsenal for study. To be returned to Firestone on completion of study. Returned from Fort Benning
<u>T137 Rifle</u> Ser. No. 1	Destroyed at Erie Ordnance Depot	
<u>T152E4 Mounts</u> Ser. No. 1 2 3 4 5 6	Fort Knox Fort Benning Fort Benning Fort Benning Fort Knox Erie Ordnance Depot	T165 ONTOS Ser. No. 5 T165 ONTOS Ser. No. 6 T166 ONTOS Ser. No. 2 T166 ONTOS T165 ONTOS Acceptance Test
<u>T152E5 Mounts</u> Ser. No. 1 2 3	Fort Benning " " Aberdeen Proving Ground	BAT Test " " Engineering Test
<u>T152E3 Mounts</u> Ser. No. 1 2 3 4	Akron Akron Akron Erie Ordnance Depot	Returned from Fort Benning Converted to E4 Converted to E4
<u>T152E2 Mounts</u> Ser. No. 1 2	Aberdeen Proving Ground Akron	To be returned Scrapped
<u>T152E1 Mount</u> Ser. No. 1	Akron	Scrapped
<u>T152 Mount</u> Ser. No. 1	Akron	Scrapped

The T137 Rifle

Excessive gas leakage at the breakdown joint of the T137E3 rifle was reported during the accelerated tests conducted at Fort Benning. A study of firing records shows that this reported excessive leakage occurs only on rounds fired with short cases, where the case does not cover the breakdown joint. Several designs for sealing this joint are under consideration and it is expected that a rifle will be modified for testing within a month.

A selective breakdown joint is also under consideration for this rifle. Such a joint would permit the rifle to be removed from the mount cradle either in one piece or as separate chamber and barrel.

The T152 Mount

Two new mounts are being manufactured. The T152E6 consists of the T152 E5 top carriage assembly mounted on a two wheeled aluminum tripod. The T152 E7 mount consists of an aluminum top carriage assembly mounted on the two

wheeled tripod of the T152E6 model. Castings are promised for delivery on or before January 10 and fabrication will proceed as rapidly as possible thereafter.

Propellant Evaluation**Double-Base Powder**

Tests made with a special double-base propellant (in four web sizes) were reported in the Twenty-Eighth Progress Report. It was found that below a certain temperature there was an increase in pressure with decreasing temperature. It was not known whether this abnormal behavior was due to grain shattering or to poor ignition.

Two web sizes of the double-base propellant were retested using T88E1 primers instead of the M57 primers used in the previous tests. The program was discontinued after the 0°F firings because of poor ignition. At 0°F there was a delay of up to 1 second after the percussion cap fired before the round went off. The data are given in Table II. No further work with this powder is planned.

Table II
Double-Base Propellents

Lot and Web	Temperature (degrees F)	Chamber Pressure (lb / sq in)	Velocity (ft / sec)
PA-E-9876 .034 in.	70	9,700	--
	70	10,400	1688
	0	8,900	1612
	0	9,100	1627
PA-E-9877 .037 in.	70	8,300	1655
	70	8,800	1649
	0	8,400	1610
	0	8,200	1549

Notes:

1. Primer was T88E1
2. Charge 9 lb. 4 oz, rifle T137E1, projectile, inert slug.

C O N F I D E N T I A L

T138 PROJECTILE

As presented in the future program of the Twenty-Eighth Progress Report a study was made to determine the interior configuration of the tee which will permit satisfactory penetration performance. The test results are given in

the Penetration Studies section of this report.

The study planned to investigate the effects of spin rate and center of gravity location is scheduled as follows:

<u>No. of rounds</u>	<u>C.G. Location In. from base</u>	<u>Twist</u>	<u>Range (yds)</u>
* 10	5.25	1/160	1500
10	5.0	1/80	1000
10	5.0	1/120	1000
10	5.0	1/160	1000
10	5.0	1/200	1000
10	5.0	1/80	1500
10	5.0	1/120	1500
10	5.0	1/160	1500
10	5.0	1/200	1500

* To complete data already obtained with T138E57 projectiles with a 5.25 in C. G. at 1/80, 1/120 and 1/200.

CONFIDENTIAL**T119 PROJECTILE****Accuracy of the T119E11 When Fired From the T19(M27) Rifle**

All of the early test firings of T119 projectiles were conducted using a T19 (M27) rifle, modified by reducing the chamber volume to about 500 cu. in. by means of a chamber liner and by enlarging the vents to provide a proper recoil balance. The modifications were made so the internal ballistics of the system would be similar to those of the BAT weapons. The accuracy of the T119 projectile from the modified system was satisfactory, and it was believed that good performance could also be obtained from an unmodified M27 rifle.

During this report period, a group of T119E11 projectiles were fired at Erie Ordnance Depot to determine the accuracy from a T19 rifle. The rifle was reconditioned by installing a new M27 breech assembly and by removing the chamber liner. A charge of 8 lb 4 oz of M10, MP propellant, .033-in. web, Lot No. PA-30240 was found to give test slugs a muzzle velocity of 1700 ft/sec. A total of 14 T119E11 rounds were fired at a 12 ft by 18 ft target at 1028 yards. Twelve hit the target. The first round fell short of the target, the second round struck high on the target and the third round, deflected by improperly positioned velocity coils, missed the target. The probable errors of dispersion for the twelve target hits, corrected to a common aiming point, were V.P.E. = $\pm .46$ mil and H.P.E. = $\pm .37$ mil. These results show that the performance of the T119E11 projectile, when fired from the T19 (M27) rifle, is satisfactory. The range data are given in Table III. A new M27 rifle has been ordered and accuracy tests will be continued when this rifle is available at Erie Ordnance Depot.

105 mm. Howitzer Tests**Strength Tests of T119E11 Projectiles**

T119E11 projectiles have been fired from a 105mm howitzer, M2A1, to determine the relative strengths of the projectile components. The results of the tests are intended to serve as guides for further development. With increasing gun pressure the first evidence of failure was an inward yielding of the projectile chamber, followed by a similar yielding in the forward portion of the projectile body.

The tail assembly, with the exception of the piston, showed no evidence of failure. In one case, complete rupture occurred at the neck of the piston.

The range data are given in Table IV and the recovered projectiles are shown in Fig. 1. It should be noted that the projectile orifice diameter was varied and that two propellant lots with different powder webs were used.

The projectile is sufficiently strong to withstand a pressure of nearly 20,000 lb/sq in. Rounds 4 and 5 in Fig. 1 were fired at 19,700 and 19,600 lb/sq in respectively, and these rounds show a very slight yielding of the chamber. An attempt was made to compensate for the crushing action of the gun pressure on the projectile chamber, by increasing the orifice diameter, but no marked effect was found.

The difference in the two propellents is especially noticeable. For a given peak pressure the slower M2 powder gives a much higher muzzle velocity.

The results of this test show that the strength of the T119E11 is more than ade-

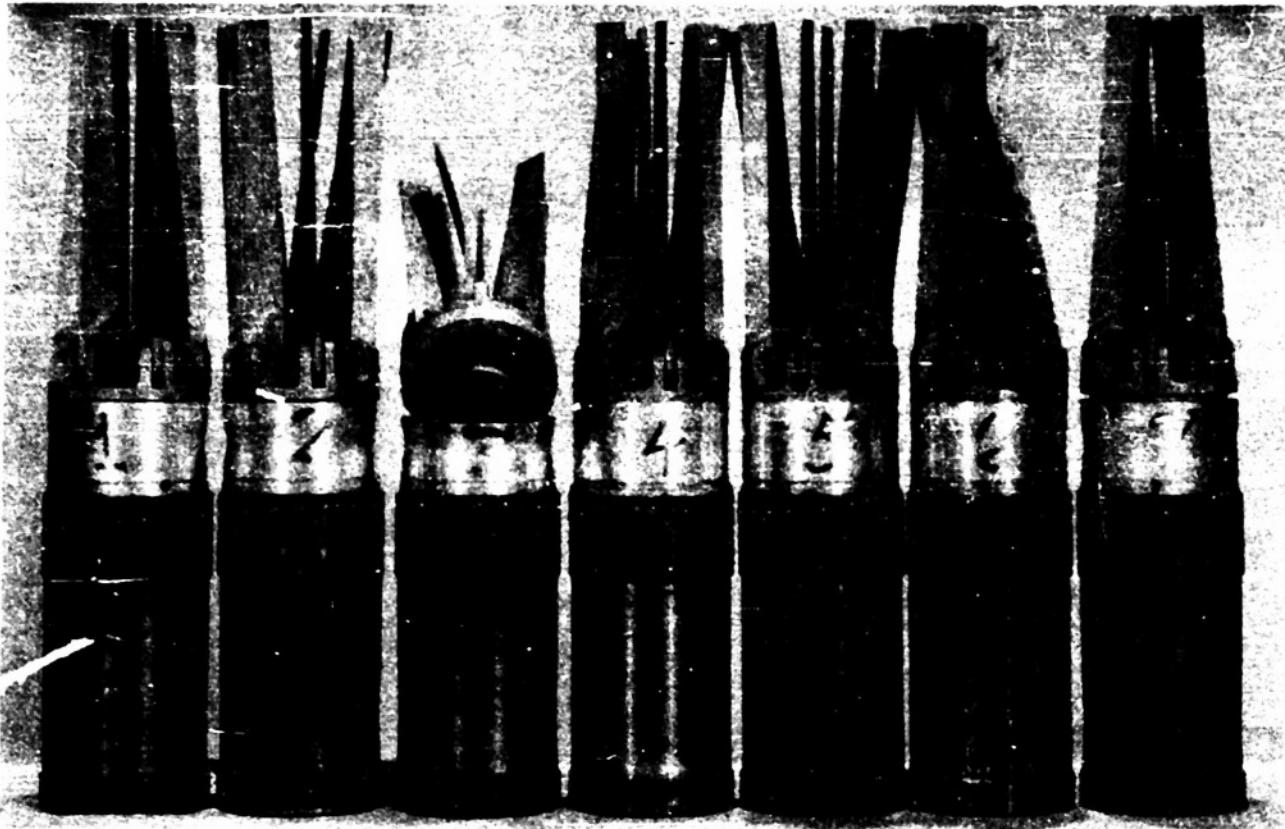


Fig. 1. Recovered Projectiles.
Firings From M2A1 Howitzer.

quate for use in existing BAT weapons, but that the strength of the chamber and body must be increased for pressures above 19,000 lb/sq in. Failure of the piston at the neck indicates marginal strength for this part and suggests a need for improvement. The design of the piston is being changed.

Charge Development and Flight Tests

Following the strength tests described above, a number of T119E1 projectiles were fired in a flight test from the 105mm howitzer, M2A1. A charge development was made and a muzzle velocity of 1700 ft/sec was obtained with a charge of 8 lb 1/2 oz of .026-in. web, M2SP propellant. Details of the charge development are given in Table V.

Nine flight rounds were then fired at a target. The results were poor; only

5 rounds struck the target. The range data for the flight test appear in Table VI.

The data in Table VI show a variation of muzzle velocity ranging from 1635 to 1727 ft/sec with a corresponding spread of chamber pressure. The projectiles were not crimped to the cartridge cases and the variations in velocity and pressure may indicate that some of the projectiles separated from the cases when chambered.

Measurements of the fin spread, taken near the muzzle, and at the target, show that the fins opened too much. Excessive fin spread is attributed to failure of the piston at the neck. This type of failure was previously observed in the rounds recovered from the strength tests described above. It is planned to repeat the tests using crimped rounds and stronger pistons.

CONFIDENTIAL**T119 Cartridge Development****Projectile Development**

Length - As now manufactured and assembled the T119E11 complete round is 39.28 in. long. Although this compares favorably with the 40.8 in. of the M323 HE and M325 WP rounds, shortening the body and ogive of the T119 projectile as shown in Fig. 2 reduces the length to 35.77 in. The material removed may be redistributed to strengthen the body and to move the center of gravity forward.

If shortness itself is desirable, the length of the T119 cartridge could be reduced to about 26 in. by using a shorter, larger diameter cartridge case. This would, however, require a new rifle with an appropriate chamber.

Fins - The performance of the T119E11 is evidence that the choice of the present six-fin configuration was judicious but no study has yet been made to determine the optimum number and size of the fins. Therefore, experiments are planned to test projectiles with fewer fins, and also with shorter fins.

Fuzing - Some preliminary penetration chamber tests (See Section on Fuzes) have been carried out using a plug-in type connector for the base element and have been found satisfactory. A new nose element with a similar type of plug-in connector will be tested soon. This type of connector simplifies assembly of the projectile and permits easier replacement of defective parts.

Projectile Shipments

Type	Date Shipped	Shipped To	Quantity
T119E11 Live	12-20-52	Picatinny Arsenal	100
T119E11 Inert	12-31-52	Aberdeen Proving Ground	30
T119E11 Inert	1-6-53	Frankford Arsenal	50

Multi-Piece Fabricated Cartridge Case

A multi-piece fabricated case is being designed to meet the request for an alternate to the cold drawn T53E1 case currently used with T119E11 rounds.

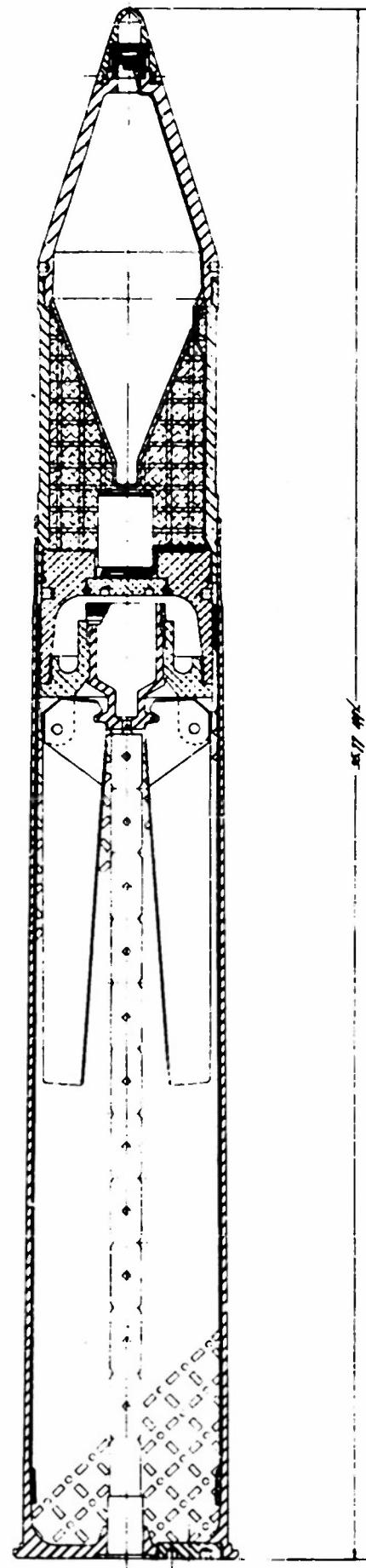
Satisfactory multi-piece fabricated cases (T53 as shown in Fig. 3) were manufactured and used successfully for T119 ammunition fired in the T137E2 rifle. Several hundred cases are still available but cannot be used in the present BAT rifles. However, there is no reason for believing that satisfactory multi-piece fabricated cases cannot be made as an alternate for any one of the cold drawn steel cases being used in 105mm recoilless rifles. The cost of making a limited number of fabricated multi-piece cases will be considerably greater than the cost of modifying the cold drawn M32 case already in large scale production. A production study is now being made to compare the capital equipment and tooling costs and the piece cost for fabricated multi-piece and drawn cases, produced at the rate of 100,000 units per month.

Relaxation of Tolerances

Experience with the T119E11 round has shown that some of the close dimensional tolerances in the fin-opening mechanism are not required. The asymmetries from tolerance variations which would ordinarily contribute to poor accuracy are apparently minimized by the slow rolling motion which is imparted to the projectile by the canted fins.

A critical study of the limit to which tolerances can be relaxed is planned. Such a study will involve accuracy firing of groups of rounds with known variations in dimensions of the fin assembly.

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Fig. 2. Short T119 Round.
For T170 or M27 Rifle.

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Technical drawing showing a cross-section of a bridge structure. The drawing includes a table of dimensions and a list of notes.

Table of Dimensions:

Item	Value	Unit
1	1.00	m
2	1.00	m
3	1.00	m
4	1.00	m
5	1.00	m
6	1.00	m
7	1.00	m
8	1.00	m
9	1.00	m
10	1.00	m
11	1.00	m
12	1.00	m
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416	1.00	m
417	1.00	m
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421	1.00	m
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423	1.00	m
424	1.00	m
425	1.00	m
426	1.00	m
427	1.00	m
428	1.00	m
429	1.00	m
430	1.00	m
431	1.00	m
432	1.00	m
433	1.00	m
434	1.00	m
435	1.00	m
436	1.00	m
437	1.00	m
438	1.00	m
439	1.00	m
440	1.00	m
441	1.00	m
442	1.00	m
443	1.00	m
444	1.00	m
445	1.00	m
446	1.00	m
447	1.00	m
448	1.00	m
449	1.00	m
450	1.00	m
451	1.00	m
452	1.00	m
453	1.00	m
454	1.00	m
455	1.00	m
456	1.00	m
457	1.00	m
458	1.00	m
459		

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Fig. 3. Multi-Piece Fabricated Case.
T13, Firestone Drawing No. DRD358.

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Table III
Accuracy Range Data
To Test Accuracy of T119E11 Projectile
From T119 (M27) Rifle

PROJECT TITLE
Model Z-112
Type ET/1
Weight (Nominal) 1,520 lbs.
C.G. Location 100.2 in.
Boulevard Ave (Nominal) 1,520 lbs.
Special Features Side fairing on

$$\left. \begin{array}{l} \text{Center of Impact } \bar{x} = -3.8, \bar{y} = -1.13 \text{ mm} \\ \text{Probable Error - Vertical } \pm 0.6 \text{ mm} \\ \text{Probable Error - Horizontal } \pm 0.97 \text{ mm} \end{array} \right\} \text{for 12 rounds}$$

Signed - G. Miller.

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Table IV
Strength Tests of T119E1 Projectiles
Fired from a Howitzer

PROJECTILE Model T119										TEST GUN			MISCELLANEOUS DATA		
Round No.	Proj. No.	Proj. Weight	Powder Charge	Powder Lot No.	Chamber Pressure	Mezze Velocity	Proj. Orifice (Diam.)	Observations	Range (Recovery) Bar.	Propellant	ChARGE W/ KNOX	ChARGE W/ KNOX			
1	X 2.97	17.62	2-4	IND 12080	22,400	1021	.196	Moderate chamber deformation; body deformed.							
2	X 2.96	17.63	2-6	"	22,600	1031	.196	Chamber body deformed; body deformed.							
3	X 2.98	17.52	2-6	"	26,900	—	.221	Normal chamber; body deformed.							
4	X 2.94	17.56	2-9	"	19,700	1776	.196	Moderate chamber deformation.							
5	X 2.97	17.64	2-3	"	19,400	—	.221	No visible deformation of chamber.							
6	X 2.90	17.62	3-10	173.2	21,800	1977	.221	Chamber deformed; piston head broken off.							
7	X 2.95	17.53	3-10	"	29,500	2092	.196	Chamber deformed; body deformed.							
4290-8	X 2.24	17.53	2-2	240-2493	17,700 34,700	1602	.206	Normal functioning and flight; No distortion of projectile body observed.							
4291-9	X 2.23	17.53	2-12	"	32,800	—	.206	Chamber collapsed; body collapsed.							

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SIGNED - O. Miller

C O N F I D E N T I A L

Table. V
Charge Development Data
T119E11 from a Howitzer

Date 12-30-42. Program T119E11
Charge Development

PROJECTILE

Model T119

Type E11

Weight (Nominal) 12.52 lb.

C.G. Location

Boreplate Dia. W.M. 2.30 in.

Special Features Guncotton Dia. 0.96 in.

SCREEN DISTANCES
6875' + 63' + 2638' Box

TEST GUN

Model 120/1 Howitzer

Type 105 mm

Length of Tube 31.67 in.

Rate of Rifling 1-20

Sighting Equipment Bore Sighted

Bore Dia. (Lands) 2.32 in.

Case - 105 mm M14 with rear loading plug

Primer M11/142

MISCELLANEOUS DATA

Range Accuracy 20%

Propellant Type M135, 100% charge w/ Kerosene

Lot No. 1312

Proof Director E. HUFFMAN

Observer _____

Round No.	Proj. No.	Proj. Weight	Powder Charge	Wind Vol. & Dir.	Chamber Pressure	Nozzle Velocity	Fin Spread			Observations
							1	2	3	
A365 - 1	X225	12.57	3-2	1/2000	1791	1760	10%	11	10%	All of these projectiles were fired with Conical nosops
A365 - 2	X269	12.54	3-0	1/2000	1662	1685	10%	10%	10%	Part of the projectiles were recovered.
A365 - 3	X280	12.53	3-4	1/2000	1626	1649	10%	10%	10%	
A365 - 4	X270	12.56	3-4	1/2000	1748	1771	10%	10%	10%	

a. Retardation Factor = .194 ft/sec/s.

b. Allowable fin spread variation: 10.0% to 10.8% of spread

Signatures: O'Miller

C O N F I D E N T I A L

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PROJECTILE									
Model <u>T-11</u>									
Type <u>4.2 in.</u>									
Weight (Nominal) <u>2,620 lbs.</u>									
Proj. No.	Proj. No.	Powder Charge	Wind	Chamber Pressure	Elev. Actual	Azimuth (mils)	Yard Cards Near Gun	Fin Spread (in.)	On Target
4-367	51469	12.63	6 - 12.6 12.63 - 21.6 12.63	16,600	—	—	—	—	—
4-368	51469	17.22	—	14,800	—	—	—	—	—
4-369	X 2.69	17.63	—	16,676	16.87	24	0	—	Missed Target
4-370	X 2.76	17.53	—	16,500	16.79	24	0	—	Missed Target
4-371	X 2.72	17.53	—	12,900	16.04	6.95	24	0	Missed Target
4-372	X 2.67	12.63	—	16,300	16.29	16.59	24	0	Missed Target
4-373	X 2.76	17.53	—	12,700	16.96	17.27	25	0	Missed Target
4-374	X 2.77	17.53	—	14,700	16.81	17.12	25	0	Missed Target
4-375	X 2.74	17.53	—	14,000	16.59	16.70	25	0	Missed Target
4-376	X 2.79	17.53	—	15,300	16.76	17.06	24.5	0	Missed Target
4-377	X 2.78	17.53	—	14,500	16.63	16.94	24.5	0	Missed Target
a. Doy nose clockwise from North. Angle of fire 15° from North.									
b. Allowable fin spread variation: 10.82 in.									

DATA TEST OF T119E11 PROJECTILES FIRED FROM M2A1 HOWITZER
TEST GUN
Model M2A1 Howitzer
Type 4.2 in.
Length of Tube 81.6 in.
Trail of Riving L-20
Sighting Equipment Elmetta Telescope
Bore Dia. (Lands) 0.125 in.
Special Features Barrel Dia. 0.196 in.

Program T119E11
Flight Test of T119E11 Projectiles Fired from M2A1 Howitzer
Range 1000 yds
Propellant Type CH-2 web. 12.6 lbs
Lot No. 17312
Proof Director E. HUFFMAN
Observer M. F. TORNIG

Round No.	Proj. No.	Proj. No.	Powder Charge	Wind	Chamber Pressure	Elev. Actual	Azimuth (mils)	Yard Cards Near Gun	Fin Spread (in.)	Observations		
										1	2	3
4-367	51469	17.32	3 - 12	—	14,800	—	—	—	—	Missed Target	Missed Target	Missed Target
4-368	51469	17.22	—	—	14,800	—	—	—	—	18.5	18.5	18
4-369	X 2.69	17.63	—	6 - 12.6 12.63 - 21.6 12.63	16,676	16.87	24	0	—	Missed Target	Missed Target	Missed Target
4-370	X 2.76	17.53	—	7 - 11.0	16,500	16.79	24	0	—	19.5	19.5	19
4-371	X 2.72	17.53	—	8 - 13.0	12,900	16.04	6.95	24	0	Missed Target	Missed Target	Missed Target
4-372	X 2.67	12.63	—	6 - 10	16,300	16.29	16.59	24	0	19.5	19.5	19.5
4-373	X 2.76	17.53	—	6 - 9.0	12,700	16.96	17.27	25	0	Missed Target	Missed Target	Missed Target
4-374	X 2.77	17.53	—	5 - 7.5	14,700	16.81	17.12	25	0	11	11	11
4-375	X 2.74	17.53	—	4 - 4.5	14,000	16.59	16.70	25	0	10.5	10.5	10.5
4-376	X 2.79	17.53	—	4 - 7.5	15,300	16.76	17.06	24.5	0	11	11	11
4-377	X 2.78	17.53	—	4 - 5.5	14,500	16.63	16.94	24.5	0	19.5	19.5	19.5
a. Doy nose clockwise from North. Angle of fire 15° from North.												
b. Allowable fin spread variation: 10.82 in.												

Signature - W.H. Brown.

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PENETRATION STUDIES

Machined Versus Drawn Liners—Effect of Standoff

Two series of DRB398 copper cones (Fig. 1, Twenty-Seventh Progress Report) were tested to determine the effect of standoff distance upon penetration. One series of DRB398 cones were drawn from copper plate, the second series were machined from hard drawn copper bar. The inspection data for the cones are shown in Tables VII and VIII. The data shown for the drawn cones are representative of the production lot of cones,

but do not include the specific cones fired. The penetration data are shown in Tables IX and X and in Fig. 4. The standoff behavior of each of the two series of cones is very similar although there is an indication that the machined cones have somewhat better penetration at the longest standoff. The greatest difference is the much reduced spread of the penetration data for the machined cones. This greater uniformity of performance is attributed to the improved symmetry of the machined liners.

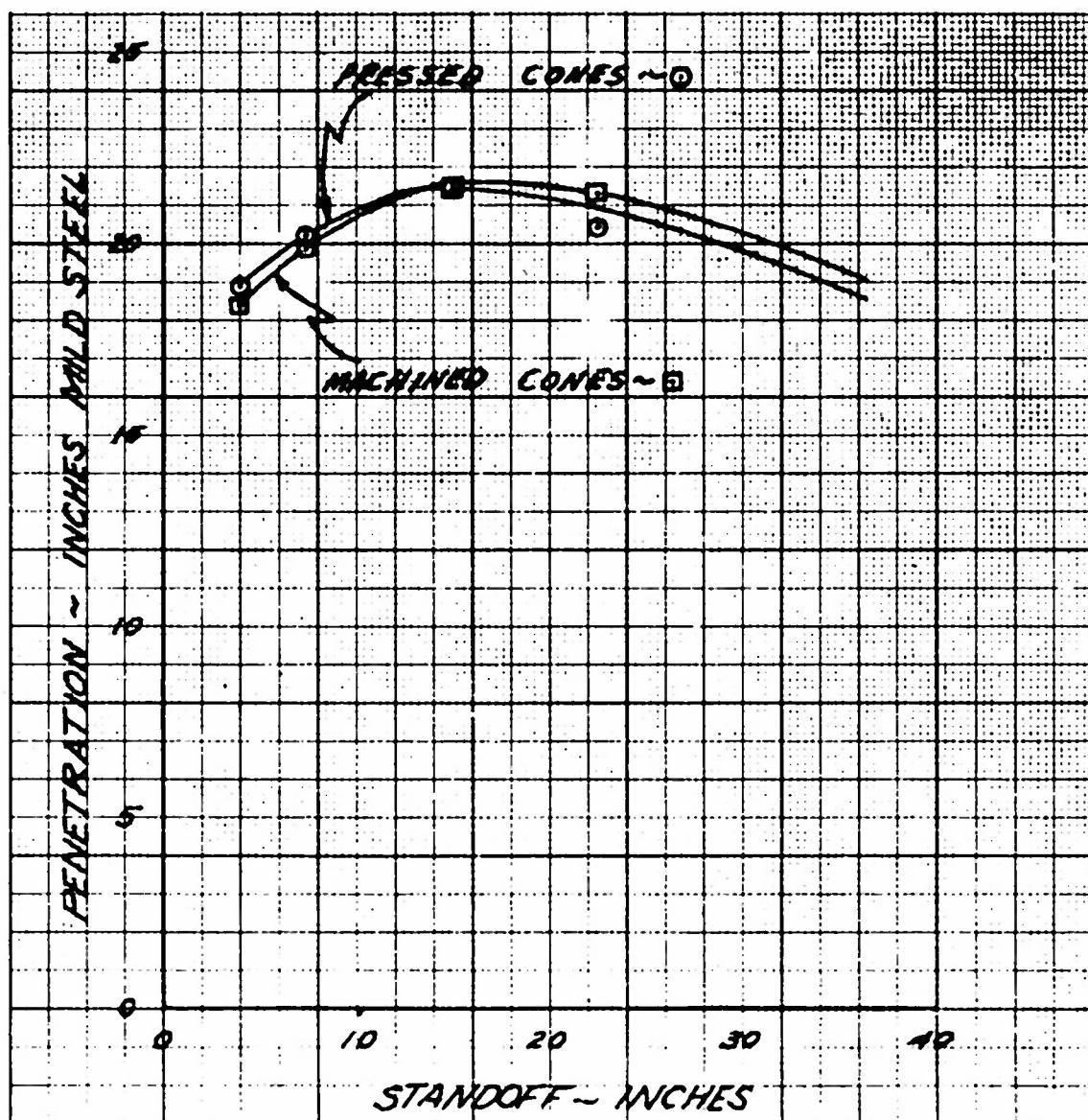


Fig. 4. Penetration Versus Standoff.
Machined and Pressed Cones.

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Table VII
Inspection Data For DRB398-6 Liners
(Machined)

Cone No.	Wall Thickness (in.)			Max. Variation W.T.		Max. Wall Waviness		Concentricity	
	Max.	Min.	Avg.	Trans.	Long.	I.D.	O.D.	Lower Datum	Upper Datum
FS-627	.1040	.1020	.1033	.0010	.0020	.0015	.0005	.0030	.0040
FS-628	.1060	.1035	.1051	.0020	.0025	.0030	.0010	.0050	.0030
FS-629	.1060	.1040	.1051	.0005	.0020	.0030	.0010	.0030	.0030
FS-630	.1060	.1030	.1046	.0005	.0030	.0040	.0015	.0030	.0020
FS-631	.1060	.1010	.1026	.0010	.0050	.0040	.0015	.0025	.0030
FS-632	.1060	.1045	.1052	.0010	.0015	.0020	.0010	.0080	.0100
FS-633	.1055	.1040	.1048	.0010	.0015	.0015	.0015	.0035	.0020
FS-634	.1030	.1025	.1029	.0005	.0005	.0025	.0000	.0030	.0025
FS-635	.1050	.1040	.1046	.0010	.0010	.0015	.0000	.0020	.0010
FS-636	.1020	.1000	.1009	.0005	.0015	.0020	.0000	.0030	.0045
FS-637	.1050	.0995	.1023	.0010	.0050	.0080	.0005	.0040	.0025
FS-638	.1090	.1050	.1068	.0010	.0040	.0050	.0005	.0040	.0045
FS-639	.1050	.1040	.1046	.0010	.0010	.0015	.0000	.0050	.0030
FS-640	.1060	.1040	.1048	.0010	.0020	.0025	.0005	.0030	.0030
FS-641	.1060	.1025	.1042	.0010	.0030	.0035	.0005	.0030	.0045
FS-642	.1065	.1050	.1058	.0010	.0015	.0020	.0005	.0020	.0025
FS-643	.1040	.1020	.1030	.0005	.0020	.0030	.0005	.0045	.0045
FS-644	.1065	.1040	.1055	.0015	.0020	.0010	.0000	.0040	.0020
FS-645	.1040	.1010	.1024	.0005	.0030	.0010	.0005	.0020	.0020
FS-646	.1065	.1040	.1053	.0010	.0015	.0020	.0005	.0030	.0015
FS-647	.1020	.1000	.1014	.0010	.0020	.0015	.0005	.0030	.0030
FS-648	.1080	.1050	.1066	.0005	.0030	.0030	.0010	.0030	.0010
FS-649	.1050	.1030	.1043	.0010	.0020	.0015	.0005	.0025	.0030
FS-650	.1050	.1035	.1043	.0010	.0015	.0010	.0005	.0040	.0045
FS-651	.1065	.1050	.1053	.0015	.0015	.0020	.0000	.0055	.0050
FS-652	.1060	.1040	.1051	.0010	.0020	.0025	.0005	.0020	.0030
FS-653	.1065	.1040	.1054	.0005	.0025	.0020	.0005	.0020	.0015
FS-654	.1050	.1020	.1038	.0010	.0030	.0030	.0000	.0080	.0080
FS-655	.1080	.1070	.1077	.0010	.0010	.0015	.0000	.0015	.0025
FS-656	.1040	.1030	.1033	.0010	.0010	.0015	.0005	.0030	.0015
FS-657	.1050	.1030	.1042	.0010	.0020	.0020	.0000	.0020	.0015
FS-658	.1050	.1040	.1047	.0010	.0010	.0015	.0005	.0025	.0015
FS-659	.0980	.0950	.0966	.0010	.0025	.0030	.0005	.0050	.0050
FS-660	.1055	.1050	.1051	.0005	.0005	.0010	.0000	.0025	.0015
FS-661	.1070	.1055	.1061	.0010	.0010	.0020	.0005	.0045	.0030
FS-662	.1045	.1035	.1041	.0005	.0010	.0010	.0000	.0040	.0010
FS-663	.1060	.1015	.1039	.0005	.0045	.0050	.0005	.0030	.0015
FS-664	.1045	.1020	.1031	.0005	.0025	.0025	.0000	.0035	.0030
FS-665	.1060	.1050	.1057	.0010	.0010	.0010	.0005	.0025	.0020
FS-666	.1040	.1010	.1025	.0010	.0025	.0030	.0005	.0035	.0030
FS-667	.1070	.1040	.1056	.0010	.0020	.0020	.0020	.0030	.0020
FS-668	.1030	.1010	.1021	.0010	.0020	.0020	.0010	.0030	.0030
FS-669	.1055	.1030	.1064	.0010	.0020	.0020	.0010	.0035	.0030
FS-670	.1055	.1040	.1049	.0015	.0015	.0025	.0050	.0040	.0040
FS-671	.1050	.1040	.1046	.0005	.0010	.0010	.0005	.0030	.0020
FS-672	.1060	.1040	.1050	.0000	.0020	.0020	.0000	.0035	.0050
FS-673	.1060	.1030	.1049	.0020	.0030	.0030	.0005	.0020	.0015
FS-674	.1075	.1040	.1057	.0010	.0035	.0040	.0010	.0020	.0020
FS-675	.1050	.1030	.1043	.0010	.0020	.0025	.0000	.0020	.0005
FS-676	.1065	.1050	.1056	.0050	.0015	.0020	.0005	.0020	.0010
FS-891	.1070	.1035	.1050	.0010	.0030	.0020	.0005	.0015	.0010
FS-892	.1080	.1035	.1055	.0010	.0045	.0045	.0005	.0045	.0035
FS-893	.1060	.1020	.1040	.0010	.0035	.0035	.0010	.0020	.0025
FS-894	.1045	.1030	.1039	.0010	.0015	.0020	.0050	.0040	.0040
FS-895	.1040	.1020	.1032	.0010	.0015	.0010	.0000	.0035	.0025
FS-896	.1010	.0975	.0994	.0005	.0035	.0035	.0000	.0035	.0070
FS-897	.1035	.1010	.1026	.0010	.0025	.0040	.0010	.0025	.0015
Avg.	.1030	.1053	.1042	.0010	.0022	.0024	.0007	.0033	.0029
Std. Dev.	± .0020	± .0018	± .0018	± .0006	± .0011	± .0011	± .0009	± .0013	± .0017
DRB-398-6 .1000	.1050	.0020	.0060	.0060	.0060	.0030	.0030		

Notes:

1. Variation in straightness or thickness of wall shall not exceed .006 in any axial plane.
2. Variation of wall thickness in any transverse plane shall not exceed .002.
3. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
4. Lower datum is .484 inch above the base; upper datum 5.202 inches above base.

C O N F I D E N T I A L

Table VIII
Inspection Data For DRB398 Liners
Drawn Cones - Lot 3

Cone No.	Wall Thickness - inches			Max.Var.Wall Thick.	Max.Wall Waviness	Concentricity (in.)			
	Max.	Min.	Avg.			I.D.	O.D.	Lower Datum	Upper Datum
Q785	.108	.104	.1062	.0015	.0030	.0025	.0015	.0065	.0070
Q786	.109	.104	.1063	.0010	.0050	.0020	.0015	.0020	.0035
Q787	.109	.105	.1068	.0010	.0040	.0015	.0010	.0020	.0015
Q788	.107	.103	.1049	.0010	.0035	.0020	.0015	.0040	.0025
Q785	.107	.102	.1056	.0010	.0040	.0030	.0015	.0040	.0025
Q790	.109	.105	.1069	.0020	.0020	.0030	.0010	.0025	.0030
Q791	.107	.103	.1059	.0025	.0040	.0040	.0015	.0015	.0020
Q792	.107	.103	.1051	.0020	.0040	.0050	.0020	.0020	.0040
Q793	.107	.104	.1051	.0015	.0030	.0020	.0005	.0040	.0010
Q794	.109	.105	.1070	.0020	.0020	.0020	.0010	.0040	.0030
Q795	.107	.103	.1052	.0020	.0025	.0020	.0005	.0040	.0035
Q796	.107	.104	.1058	.0010	.0025	.0020	.0005	.0030	.0025
Q797	.107	.104	.1052	.0010	.0030	.0020	.0000	.0025	.0080
Q798	.107	.105	.1060	.0020	.0025	.0025	.0005	.0025	.0065
Q799	.108	.104	.1057	.0020	.0040	.0040	.0010	.0020	.0015
Q800	.107	.105	.1061	.0020	.0015	.0020	.0005	.0020	.0055
Q801	.107	.104	.1058	.0025	.0025	.0020	.0010	.0025	.0030
Q802	.108	.106	.1072	.0015	.0020	.0025	.0025	.0035	.0065
Q803	.108	.104	.1063	.0025	.0040	.0030	.0030	.0025	.0015
Q804	.108	.104	.1061	.0020	.0030	.0030	.0015	.0025	.0065
Q805	.108	.105	.1067	.0030	.0020	.0010	.0015	.0040	.0015
Q806	.107	.105	.1060	.0010	.0020	.0030	.0020	.0015	.0010
Q807	.106	.102	.1039	.0015	.0040	.0030	.0020	.0020	.0035
Q808	.109	.102	.1046	.0030	.0060	.0065	.0010	.0080	.0060
Q809	.108	.105	.1069	.0015	.0030	.0020	.0020	.0020	.0085
Q810	.106	.104	.1053	.0020	.0015	.0030	.0010	.0035	.0070
Q811	.107	.103	.1048	.0015	.0040	.0030	.0030	.0020	.0050
Q812	.107	.103	.1052	.0010	.0040	.0040	.0015	.0015	.0030
Q813	.108	.105	.1068	.0025	.0030	.0025	.0015	.0050	.0060
Q814	.108	.103	.1058	.0020	.0040	.0030	.0025	.0030	.0030
Q815	.107	.103	.1051	.0025	.0035	.0035	.0015	.0055	.0070
Q816	.107	.102	.1050	.0030	.0050	.0025	.0020	.0055	.0100
Q817	.109	.105	.1068	.0015	.0030	.0025	.0015	.0025	.0070
Q818	.107	.103	.1051	.0020	.0040	.0040	.0015	.0010	.0035
Q819	.105	.102	.1038	.0020	.0025	.0030	.0010	.0020	.0050
Q820	.106	.104	.1056	.0025	.0020	.0025	.0010	.0055	.0065
Q821	.108	.106	.1071	.0005	.0010	.0020	.0010	.0015	.0035
Q822	.108	.104	.1062	.0015	.0030	.0030	.0020	.0035	.0035
Q823	.109	.103	.1063	.0040	.0030	.0035	.0010	.0030	.0035
Q824	.108	.103	.1050	.0040	.0030	.0035	.0010	.0055	.0055
Q825	.106	.104	.1054	.0020	.0020	.0020	.0020	.0045	.0035
Q826	.108	.104	.1064	.0015	.0035	.0035	.0015	.0045	.0040
Q827	.106	.104	.1049	.0010	.0020	.0040	.0010	.0025	.0065
Q828	.106	.102	.1046	.0040	.0040	.0045	.0020	.0035	.0015
Q829	.108	.105	.1064	.0010	.0030	.0020	.0020	.0040	.0045
Q830	.108	.105	.1064	.0020	.0030	.0030	.0020	.0045	.0050
Q831	.108	.105	.1066	.0020	.0020	.0020	.0015	.0035	.0010
Q832	.108	.102	.1052	.0050	.0030	.0040	.0015	.0015	.0020
Q833	.109	.105	.1074	.0040	.0020	.0030	.0010	.0025	.0045
Q834	.107	.105	.1061	.0020	.0020	.0020	.0010	.0050	.0060
Avg.	.1075	.1039	.1058	.0020	.0030	.0029	.0014	.0033	.0061
Std. Dev.	±.0009	±.0011	±.0008	±.0009	±.0008	±.0014	±.0006	±.0015	±.0029
Specifications:	.105	.100	--	.0020	.0060	.0060	.0060	.0030	.0030
Notes:	<ol style="list-style-type: none"> 1. Variation in straightness or thickness of wall shall not exceed .006 in any axial plane. 2. Variation of wall thickness in any transverse plane shall not exceed .002. 3. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis. 4. Lower datum is .484 inch above the base; upper datum 3.202 inches above base. 								

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Table IX
Penetration Data
DRB398 Machined Cones—Effect of Standoff

Round No.	Lbs.Comp B	Standoff (inches)	Penetration inches M.S.	Max. Spread (in.)	Std.Dev. (in.)
FS627	2.58	4.0	18.19		
FS628	2.58	"	18.50		
FS629	2.58	"	18.50		
FS630	2.56	"	18.19		
FS631	2.58	"	18.56		
			Avg. 18.39	0.37	±.18
FS632	2.58	7.5	19.94		
FS633	2.58	"	20.56		
FS634	2.60	"	19.56		
FS635	2.58	"	19.12		
FS636	2.58	"	20.50		
			Avg. 19.93	1.44	±.62
FS637	2.58	15.0	21.88		
FS638	2.56	"	20.75		
FS639	2.58	"	20.81		
FS640	2.58	"	22.31		
FS641	2.58	"	21.75		
			Avg. 21.50	1.56	±.69
FS642	2.60	22.5	19.81		
FS643	2.58	"	22.25		
FS644	2.60	"	21.69		
FS645	2.58	"	22.00		
FS646	2.58	"	20.62		
			Avg. 21.27	2.44	±1.03

Notes:

1. Cones assembled in DRC376 test bodies with nose rings.
2. All rounds were fired at Erie Ordnance Depot at 0 rev/sec.
3. Rounds loaded at Ravenna Arsenal, BAT Lot No. 23 with Composition B, Holston Lot 3-126.

Table X
Penetration Data
DRB398 Pressed Cones—Effect of Standoff

Round No.	Lbs.Comp B	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Dev. (in.)
FS851	2.58	4.0	19.31		
FS852	2.58	"	19.38		
FS853	2.60	"	19.18		
FS854	2.58	"	18.25		
FS855	2.60	"	18.19		
			Avg. 18.86	1.19	±0.59
FS856	2.58	7.5	21.00		
FS857	2.58	"	18.94		
FS858	2.60	"	22.18		
FS859	2.58	"	19.38		
FS860	2.58	"	19.38		
			Avg. 20.18	3.24	±1.37
FS861	2.56	15.0	22.25		
FS862	2.56	"	19.31		
FS863	2.58	"	22.06		
FS864	2.56	"	23.18		
FS865	2.60	"	20.31		
			Avg. 21.42	3.87	±1.57
FS866	2.58	22.5	18.06		
FS867	2.58	"	18.25		
FS868	2.58	"	23.75		
FS869	2.58	"	21.62		
FS870	2.60	"	20.44		
			Avg. 20.42	5.69	±2.39

Notes:

1. Cones assembled in DRC376 test bodies with nose rings.
2. All rounds were fired at Erie Ordnance Depot at 0 rev/sec.
3. Rounds loaded at Ravenna Arsenal, BAT Lot #22 with Composition B, Holston Lot 3-126.

Effect of Tee Configuration

Further studies of the effect of internal configuration of the tee upon penetration were conducted. Fig. 5 shows the DRC314 tee and the two modifications studied. The penetration data are shown in Table XI. The average penetration of the DRB 398 drawn cones fired with DRC314 tees is 16.01 inches. (Table VI, Twenty-Seventh Progress Report). The DRC314 HW10 tee allows 16.2 inches and the DRC 314 HW14 tee 18.24 inches. The principal difference between these two modifications is that the DRC314HW14 tee allows approximately .25 inch more space in front of the cone than does the DRC314 HW10. It now seems that of the several tee modifications tested the DRC314 HW11 tee (Twenty-Seventh Progress Report) and the DRC314 HW14 cause the least reduction in penetration.

Comp B Loading; Effect of Riser Material

Ten rounds, with DRB398 cones and DRC376 bodies, were poured using two different types of pouring funnels or risers to determine the effect upon penetration performance. The basic design of the two risers is similar, as shown in Fig. 6 but one is made of aluminum, the other of glazed chemical porcelain. The greater thermal conductivity of aluminum makes the center hole necessary to prevent premature freezing off of the charge. The center hole is not necessary with porcelain risers. Charges poured using porcelain risers show some surface discoloration (yellowing) of the Composition B where it contacts the porcelain. This test was undertaken to determine whether the difference in risers and consequent rate of cooling, etc. has an effect upon

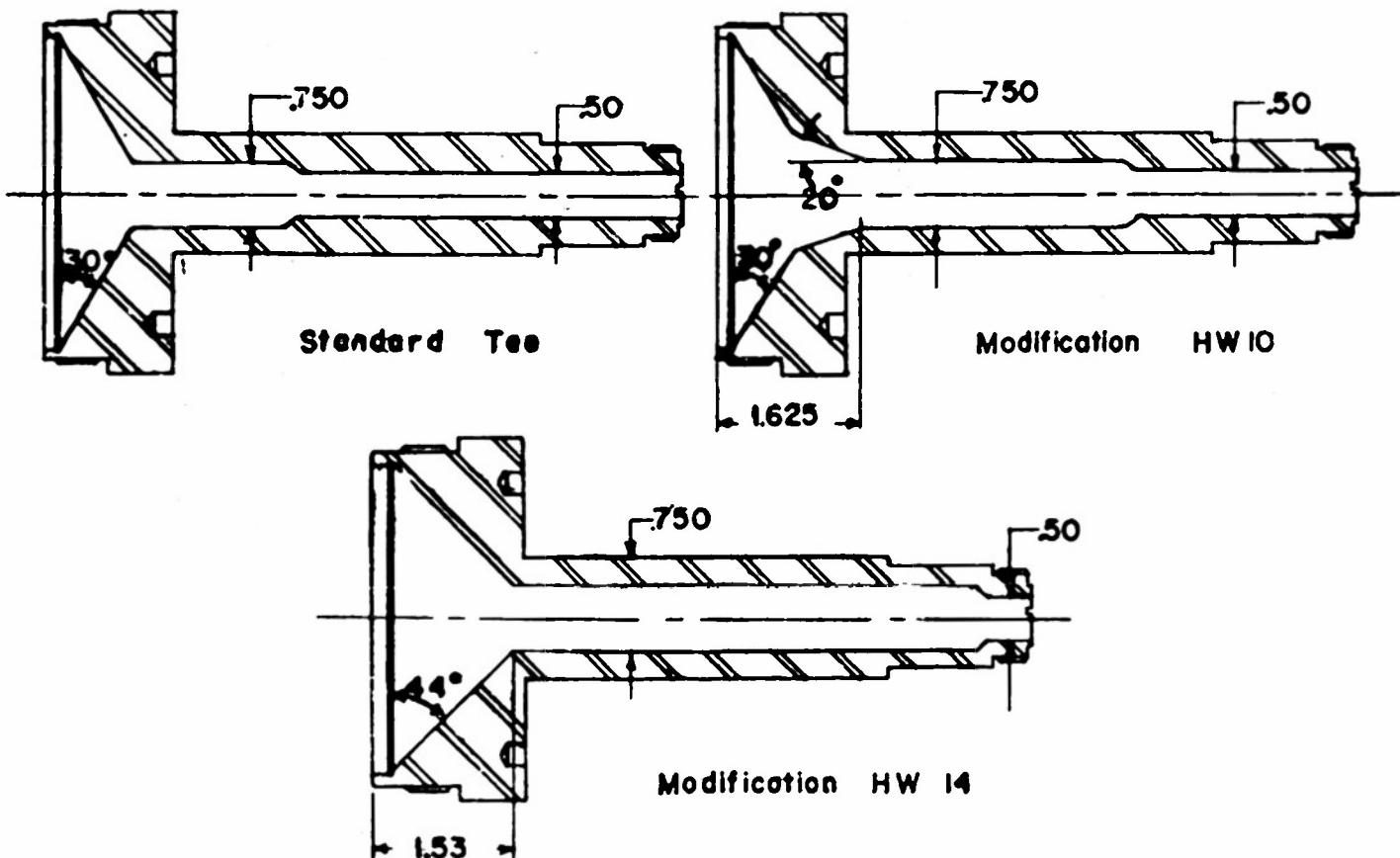


Fig. 5. DRC314 Tee and Two Modifications.

penetration. The penetration data are shown in Table XII. The charges cast using aluminum risers penetrated about 5% (1.0 inch) more than did the others.

Malleable Iron Tees

T138 projectiles have a long slender tee or boom which usually enters the cavity created by the shaped charge jet and effectively seals the hole. It has never been determined whether this is desirable or undesirable. To see whether a tee made of a material more brittle

than mild steel would break up instead of plugging the cavity, tests with two types of malleable iron have been conducted. One type is made of malleable iron having an elongation at break of from 16% to 20%, the other is made of manganese enriched malleable iron having an elongation at break of from 5% to 8%. All tees are made to drawing DRC314-16 except for material. The penetration data are shown in Table XIII. No differences between the performances of these two types of malleable iron and mild steel were observed.

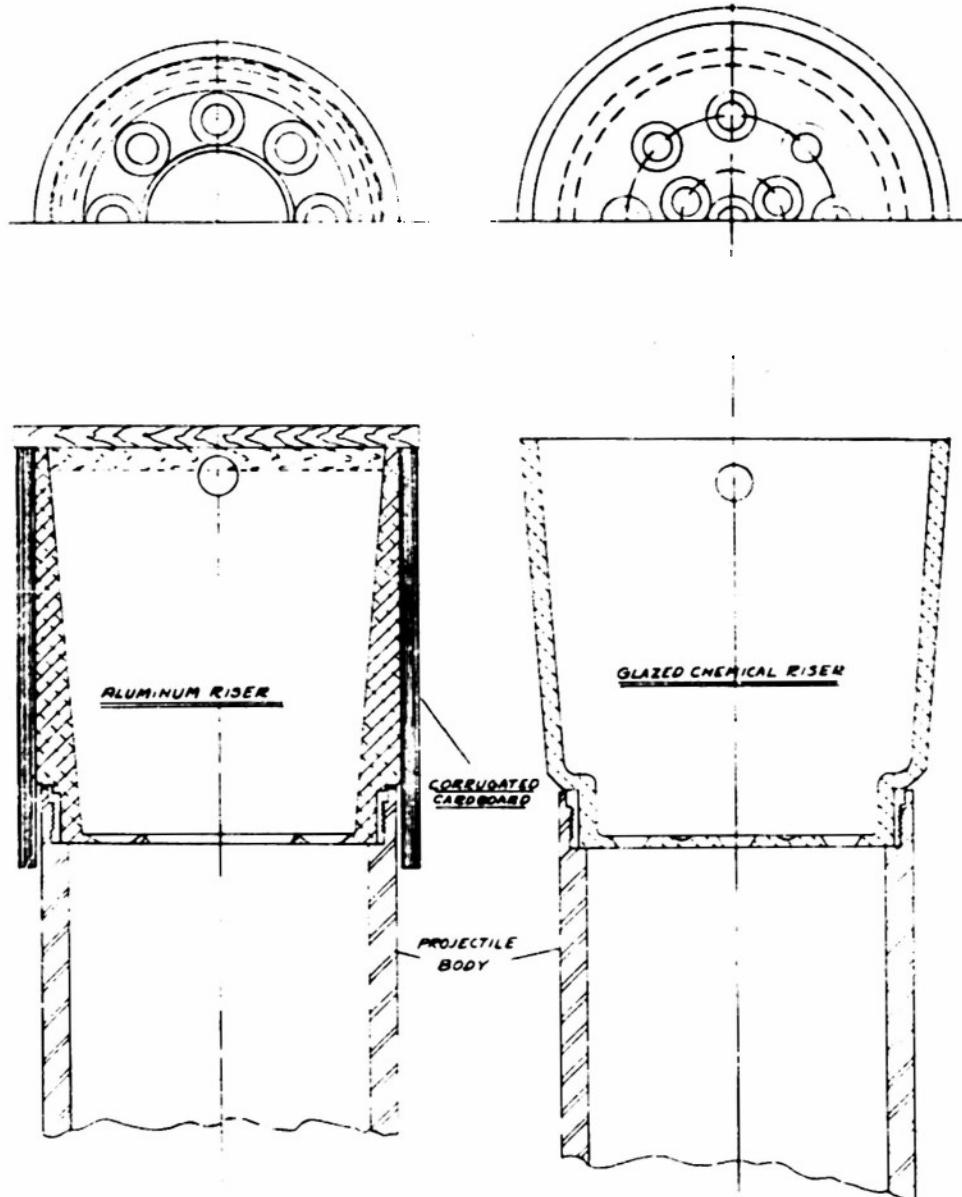


Fig. 6. Two Types of Risers.
For Loading High Explosives.

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Table XI
Penetration Data
With DRC314 HW10 Tee

Round No	Lbs.CompB	Rev/Sec	Penetration (in.)	Max.Spread (in.)	Std. Dev. (in.)
(With DRC314 HW10 Tee)					
Q745	2.56	0	19.12		
Q746	2.58	"	13.94		
Q757	2.58	"	14.62		
Q758	2.58	"	16.75		
Q775	2.58	"	16.56		
			Avg. 16.20	5.18	±2.03
(With DRC314 HW14 Tee)					
Q747	2.60	0	18.06		
Q748	2.56	"	18.62		
Q749	2.58	"	19.12		
Q750	2.58	"	16.88		
Q751	2.58	"	18.50		
			Avg. 18.24	2.24	±.85
Notes:					
1. DRC376 bodies and plugs; booster in base plug.					
2. Loaded at Ravenna Arsenal, BAT Lot #21 (HW10), BAT Lot #23 (HW14), with Composition B, Holston Lot 3-126.					
3. All rounds fired at Erie Ordnance Depot.					

Table XII
Penetration Data
Effect of Riser Type

Round No	Lbs.CompB	Rev/Sec	Penetration (in.M.S.)	Max. Spread (in.)	Std. Dev. (in.)	Remarks
Q735	2.54	0	20.00			Al. Riser
Q736	2.54	"	18.56			" "
Q739	2.56	"	20.56			" "
Q742	2.56	"	19.18			" "
Q743	2.58	"	20.75			" "
			Avg. 19.81	2.19	±0.93	
Q737	2.54	0	18.75			Porcelain
Q738	2.56	"	20.75			"
Q740	2.56	"	17.38			"
Q741	2.56	"	19.06			"
Q766	2.60	"	18.50			"
			Avg. 18.89	3.37	±1.22	
Notes:						
1. Assembled in DRC376 test bodies with nose rings.						
2. Loaded at Ravenna Arsenal, BAT Lot #21 with Composition B, Holston Lot 3-126.						
3. All rounds fired at Erie Ordnance Depot at 7.5" standoff.						

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Table XIII
 Penetration Data
 Tee Material Study

Round No.	Lbs. Comp B	Type Tee	Penetration (inches M.S.)	Max. Spread (in.)	Std. Dev. (in.)	Remarks
Q752	2.58	Reg. Malleable Iron	13.94			Tee in target
Q753	2.62	" " "	17.12			" " "
Q754	2.60	" " "	17.81			" " "
Q755	2.60	" " "	16.81			Tee not in target
Q756	2.58	" " "	11.94			" " " "
			Avg. 15.52	5.87	±2.49	
Q759	2.62	High Manganese	14.31			Tee in target
Q760	2.64	" "	16.69			" " "
Q772	2.61	" "	17.31			" " "
Q773	2.69	" "	15.38			" " "
Q774	2.60	" "	17.94			" " "
			Avg. 16.33	3.63	±1.47	
Notes:						
1. Assembled in DRC376 test assemblies.						
2. Loaded at Ravenna Arsenal, BAT Lot No. 20 with Comp B, Holston Lot 3-126.						
3. All rounds fired at Erie Ordnance Depot at 0 rev/sec.						
4. Standoff is 7.32 in.						

C O N F I D E N T I A L

F U Z E S

Explosive Train and Detonator Safety
Tests On T222E5 Base Elements

Sixteen base elements, DRD328, (Fig. 10 of the Twenty-Fifth Progress Report) were modified to bring the leads of an M36 detonator out of the rear of the base element, with the rotor in the armed position. M36 detonators were substituted for T18 detonators for safety in handling. Each base element had one tetryl lead (PA-E-11458) and one tetryl pellet (PA-E-11459). The loaded and armed base elements were mounted in T138 base plugs (DRB410), as shown in Fig. 7, and were placed tetryl end down on witness plates of 3/4-in. homogeneous armor plate and fired in the penetration chamber at Erie Ordnance Depot. Fifteen of these assemblies were initiated using a 1.5-volt flashlight battery and gave high order detonations; the other failed to function high order. Fig. 8 is a photograph of the witness plate.

For comparison, the center hole, with the added crater, shown in Fig. 8, was produced by two P82466 pc mk C tetryl pellets fired by an M36 detonator placed in the center hole of the pellets. The crater was probably produced either by the M36 detonator or by the cavity (shaped charge) effect of the hole in the tetryl pellets.

To test the detonator safety of T222E5 base elements (DRD328), two base elements were fired as described above, using M36 detonators, tetryl leads (PA-E-11458) and tetryl pellets (PA-E-11459) except that the rotor was in the unarmed position. The detonator in each assembly was heard to explode but no external marks were apparent. The base elements were not disassembled for inspection; they were destroyed by firing with tetryl pellets placed on the outside.

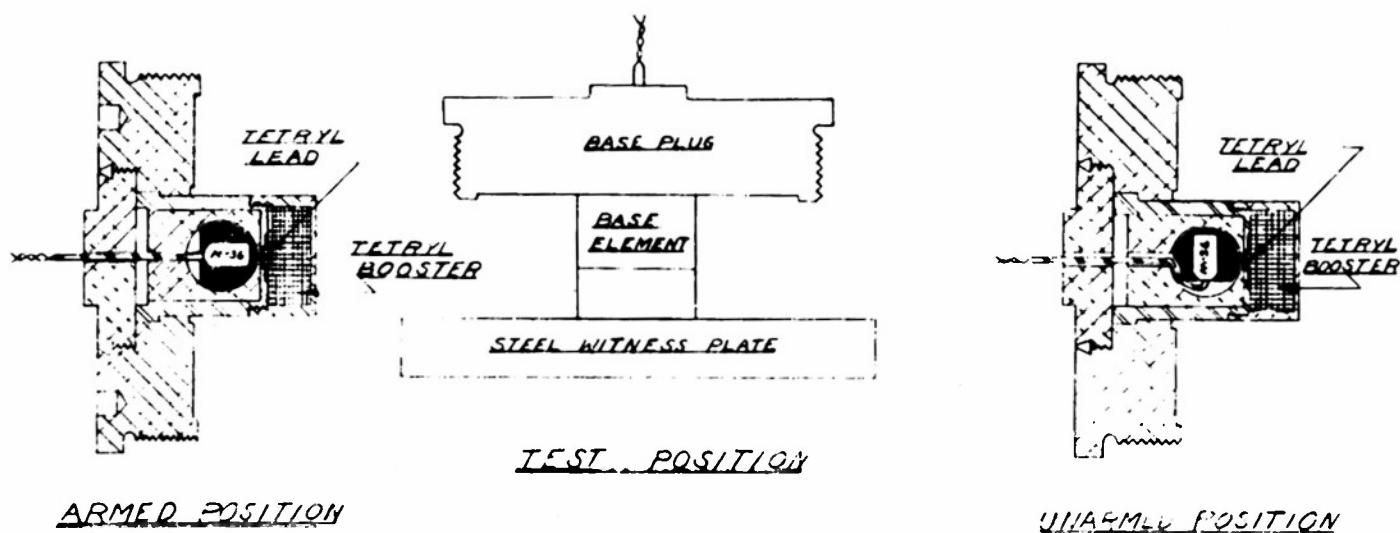


Fig. 7. Base Element Test Assembly.

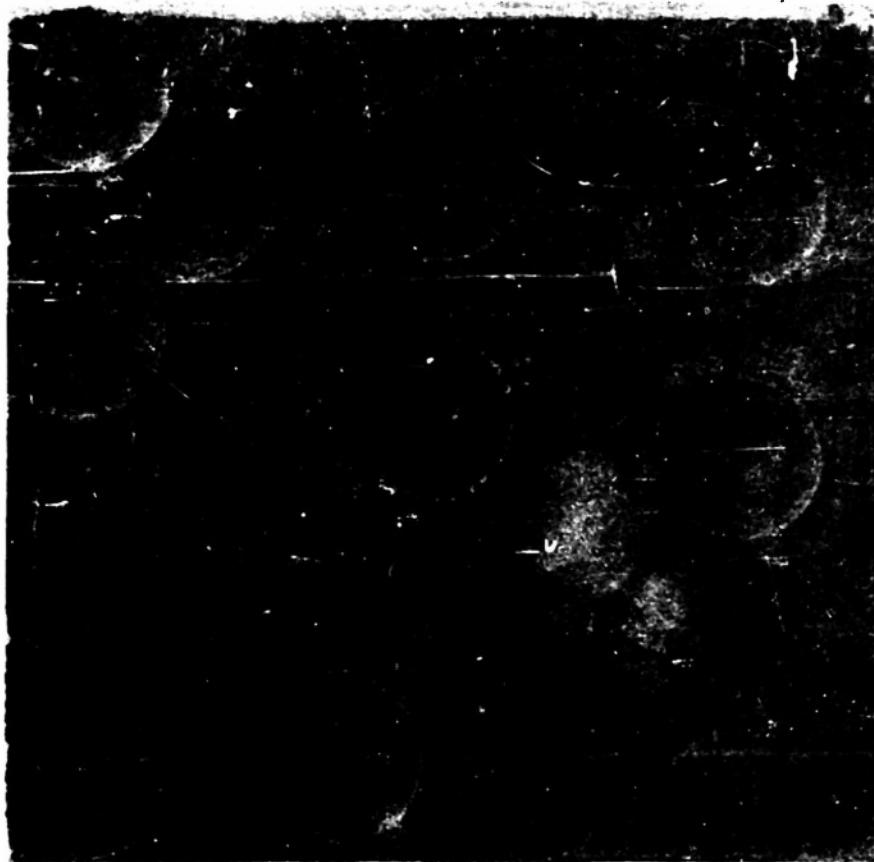


Fig. 8. Photograph of Witness Plate.

Comparison of T222E5 and T208E5 Base Elements for Explosive Train Effectiveness

Five T222E5 base elements (DRD328) and five T208E5 base elements were fired to compare the brisance effect on 3/4-in. homogeneous armor plate. Both types of base elements were equipped with M36 rather than T18 detonators and were modified as shown in Fig. 7 to bring the leads out through the base. The T222E5 base elements had PA-E-11458 tetryl leads and PA-E-11459 tetryl pellets. The T208 E5 base elements had their standard tetryl pellets, but no tetryl lead pellets or cups. Two T208E5 base elements gave high order performances, two gave somewhat poorer performance and one resulted in a low order detonation. All five T222 E5 base elements gave high order performances. Fig. 9 and Fig. 10 show the depressions produced in the armor plate.

DRC439 Fuzing System

Five penetration assemblies as shown in Fig. 11, including the elements of a DRC439 fuzing system, were prepared. These assemblies were loaded at Ravenna Arsenal and fired at Erie Ordnance Depot. Table XIV shows the results of this penetration study.

Comparison of these data with those of standard penetration assemblies (Item IIa, Table VI, Twenty-Seventh Progress Report) indicates that the performance is satisfactory. Use of this fuzing system simplifies the loading and handling of HEAT rounds because the base elements are plugged into place thereby eliminating the necessity of protecting the lead wire during loading of the shell and of attaching the lead wire to the terminal on the base element.

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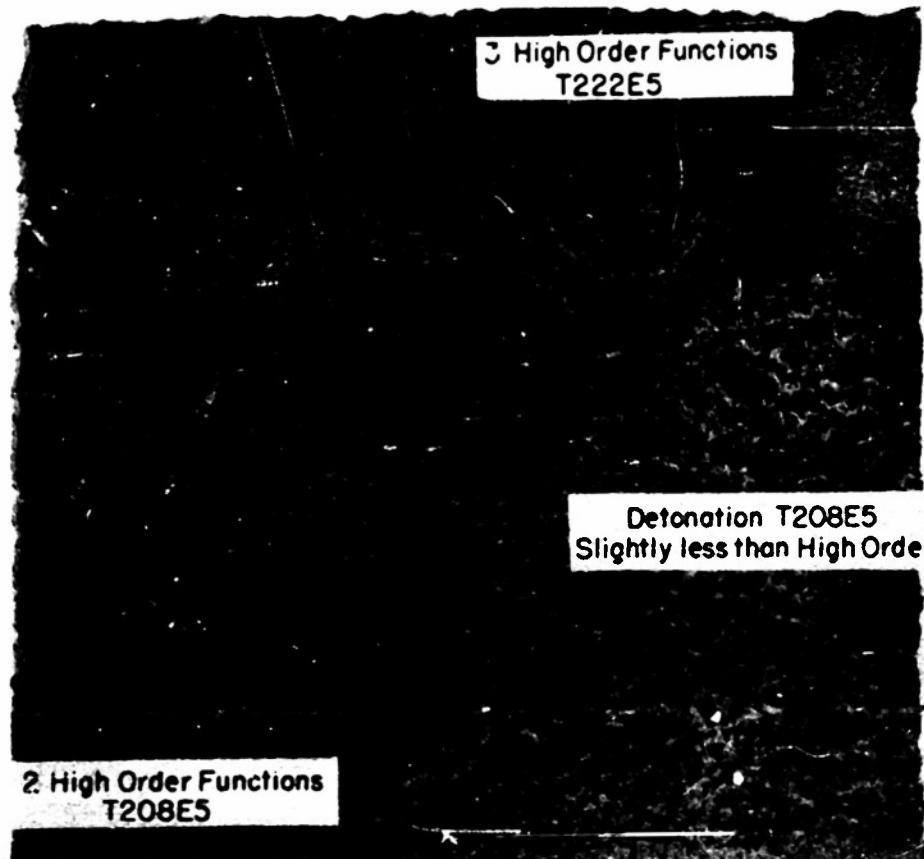


Fig. 9. Depressions in Armor Plate.

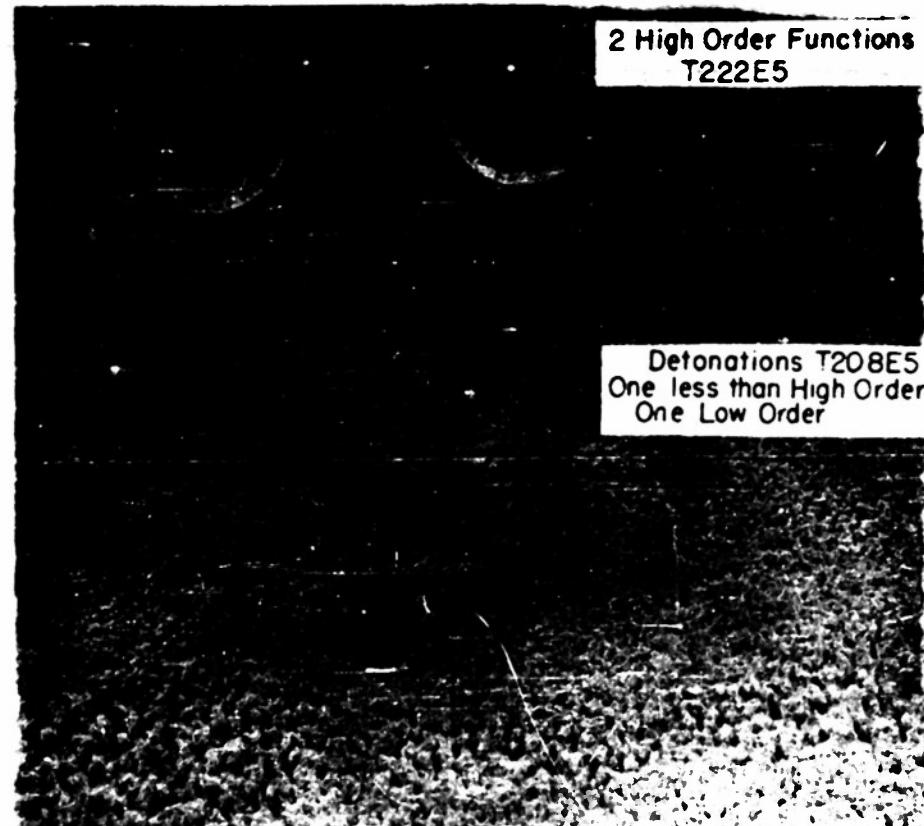
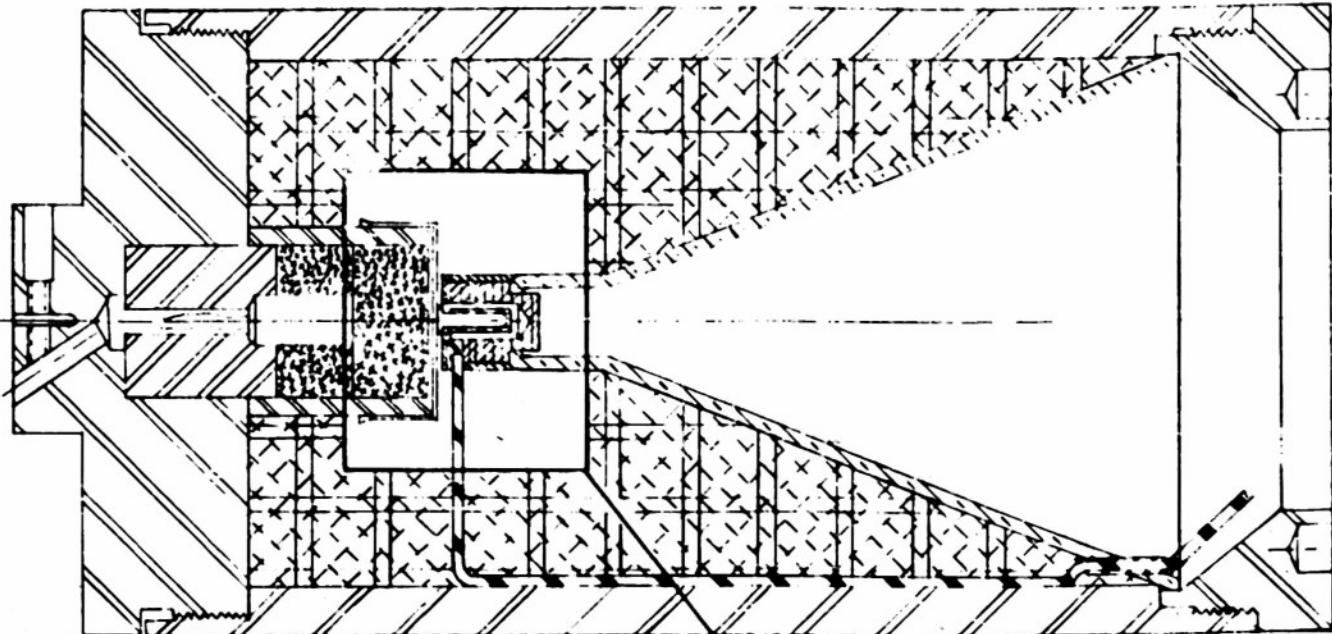


Fig. 10. Depressions in Armor Plate.

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PORTION OF DRC439 SYSTEM
TESTED. SEE TABLE XIV.

Fig. 11. Penetration Assembly.

Table XIV
Penetration of Rounds Using DRC439 Fuzing System

Round No.	Spin Rate (rev/sec)	Standoff (in.)	Penetration (in.)
FS846	0	7.5	20.44
FS847	0	7.5	19.38
FS848	0	7.5	18.50
FS849	0	7.5	18.31
FS850	0	7.5	19.88
Avg.			19.30